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ABSTRACT

The focus of this document is on the design of educational facilities, especially workshops, in Singapore. Chapter 1 discusses secondary schools, including the general curriculum and specifications-of-space provision in a standard secondary school. In chapter 2 the position of technical education within general secondary schools is addressed. Chapter 3 focuses on general design considerations of workshops, such as location, size, placement of machinery and equipment, ventilation, and lighting. Detailed design considerations for metal work, woodwork, wood machine, electricity and electronics, and technical drawing shops are discussed in chapter 4. General workshop rules are appended. (YLB)

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EDUCATIONAL BUILDING REPORT 11

# Workshops in secondary schools, Singapore

*by Michael Liew Kok-Pun*
*Pang Kia Seng*
*Harbans Singh*

CE 023 998

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Chapter One

# SECONDARY SCHOOLS IN SINGAPORE

## Background

Since 1959, the Government of Singapore has pursued a policy of ensuring that every child of school-going age is provided a place in school. This has led to an increasingly heavy programme of the construction of school buildings. The limited land area of the Republic - some 586 square kilometres - coupled with a population of more than two million, forms a severe constraint to all building projects on the island. The optimum use of land is thus an important element in physical planning - as it is in many of the large cities in other countries of the region of Asia and Oceania.

In Singapore, where multi-storey housing is accepted as the reasonable solution for living, there appears to be no strong, quantitative argument against multi-storied schools. As a result, there has been a tendency to increase the number of storeys in schools to make the best possible use of the available land. Coupled with this intensive use of sites is the policy of more intensive use of existing buildings. This has resulted in the operation of school facilities on a double-, or even in some cases, treble-shift system. The third shift is arranged in the evening for classes in adult education.

Secondary education in Singapore consists of a four-year educational programme for students within the age-range of 12-16 years. The programme, which leads to the Singapore - Cambridge General Certificate of Education (Ordinary Level) Examination, includes a common curriculum in the first two years and a diversified curriculum in the third and fourth years.[1] During these last two years, the student follows a core curriculum and is able to specialize by selecting subjects which are biased towards science, arts, commerce or technical education. It is the facilities for specialized instruction for technical education throughout secondary general education that form the subject of this Report.

## The general curriculum

Tables 1, 2 and 3 give the curriculum for general secondary education in Singapore. It will be seen that the strictly technical components which require specialized instructional spaces are technical drawing, woodwork,

1. At the time of finishing the script of this publication, major changes in the lower secondary curriculum had been made. Briefly, the changes concern *the abolition of automatic promotion*, the withdrawal of Technical Drawing and Basic Electricity from the Secondary 1 and 2 curricula, and the channelling of non-academically-inclined pupils to the Industrial Training Board or the Adult Education Board courses.

metalwork and basic electricity and electronics. The spaces for these activities are located in a separate workshop the location of which, in relation to the other components of a standard secondary school, is shown in Figure 1. The general allocation of space in such a school, including the spaces for the technical component, is given in Table 4. The areas per place are shown in Table 5.

Table 1. Common curriculum for Secondary 1 classes

| Subjects | No. of periods per week[1] |
|---|---|
| First language and literature | 8 |
| Second language | 6 |
| Mathematics | 5 |
| General science | 6 |
| History and geography | 4 |
| Art and crafts | 2 |
| National language | 1 |
| Physical education | 2 |
| Civics | 1 |
| Music/singing | 1 |
| Assembly | 1 |
| Technical subjects (Metalwork) (Woodwork) | 3 |
| Home economics[2] | 3 |
| | 40 |

1. Each period is about 35–40 minutes in duration.
2. Girls pupils taking Home economics will not take Technical subjects.

Table 2. Common curriculum for Secondary 2 classes

| Subjects | No. of hours per week[1] | | |
|---|---|---|---|
| | Boys | Girls | |
| | | Taking technical subjects | Not taking technical subjects |
| First language and | 5h | 5h | 5h |
| Second language | 3h, 45′ | 3h, 45′ | 3h, 45′ |
| National language | 1h, 15′ | – | 1h, 15′ |
| Mathematics | 3h, 05′ | 3h, 05′ | 3h, 05′ |
| General science | 3h, 45′ | 3h, 45′ | 3h, 45′ |
| Physical education | 1h, 15′ | 1h, 15′ | 1h, 15′ |
| Civics | 40′ | 40′ | 40′ |
| Assembly | 40′ | 40′ | 40′ |
| History ) Geography ) | 2h, 30′ | 2h, 30′ | 2h, 30′ |
| Home economics | – | 1h, 15′ | 3h, |
| Art and crafts | 1h, 15′ | 1h, 15′ | 1h, 15′ |
| Music/singing | 35′ | 35′ | 35′ |
| Technical drawing | 1h, 15′ | 1h, 15′ | 1h, 15′[3] |
| Metalwork ) Woodwork ) Basic electricity ) | 3h[2] | 3h[2] | |
| Total | 28 | 28 | 28 |

1. Minor adjustments are made by schools where necessary.
2. Normally outside school hours.

Table 3. Secondary 3 and 4 curricula

| Subjects | Periods per week | Remarks |
|---|---|---|
| **Technical stream** | | |
| A. Compulsory Examination Subjects | 26 | |
| 1. First Language | | |
| 2. Second Language | | |
| 3. Elementary Mathematics | | |
| 4. Physical Science | | |
| 5. Technical Drawing | | |
| B. Compulsory Non-Examination Subjects | | |
| 1. Civics/Current Affairs | 2 | |
| 2. Physical Education | 2 | |
| 3. Assembly Talks | 1 | |
| 4. Music Appreciation/Singing | 1 | |
| C. Elective Examination Subjects Choose 1 or 2 | 9 | Special approval required for 3 electives. |
| 1. Additional Mathematics | | |
| 2. Biology | | |
| 3. Human and Social Biology | | C 2 may not be taken with C 3 |
| 4. Woodwork | | One of C 4, C 5 and C 6 must |
| 5. Metalwork | | be taken. |
| 6. Basic Electricity and Electronics | | |
| 7. Literature or History or Geography | | |
| Total | 41 | |
| **Non-technical stream** | | |
| A. Compulsory Examination Subjects | 26 | |
| 1. First Language | | |
| 2. Second Language | | |
| 3. Elementary Mathematics | | |
| 4. A Science subject or Home Economics | | |
| 5. Literature or History or Geography | | |

Table 3. Secondary 3 and 4 curricula (cont'd)

| Non-technical stream | | |
|---|---|---|
| Subjects | Periods per week | Remarks |
| B. Compulsory Non-Examination Subjects | | |
| 1. Civics/Current Affairs | 2 | |
| 2. Physical Education | 2 | |
| 3. Assembly Talks | 1 | |
| 4. Music Appreciation/Singing | 1 | |
| C. Elective Examination Subjects Choose 1 or 2 | 9 | Special approval required for 3 electives. Not more than 2 Science subjects (including A 4) for any student. |
| 1. Additional Mathematics | | |
| 2. Biology | | |
| 3. Human and Social Biology | | C 2 may not be taken with C 3. |
| 4. Physical Science | | |
| 5. General Science | | C 4 may not be taken with C 5. |
| 6. Literature | | |
| 7. Geography | | |
| 8. History | | |
| 9. Art and Crafts | | |
| 10. Needlework and Dressmaking | | |
| 11. Cookery | | |
| 12. General Housecraft | | |
| 13. Commercial Studies | | C 13 may not be taken with C 14. |
| 14. Commerce | | |
| 15. Principles of Accounts | | |
| 16. Music | | |
| 17. Bible Knowledge | | C 17 may not be taken with C 18. |
| 18. Islamic Religious Knowledge | | |
| Total | 41 | |

Table 4. Space provision in a standard secondary school in Singapore

| Space | No. of units | Unit area (in $m^2$) | Total area (in $m^2$) |
|---|---|---|---|
| 1. Instructional Area | | | |
| Classroom | 28 | 64 | 1 792 |
| Special Room | 4 | 89 | 356 |
| Technical Facilities | | | |
| Metal Workshop I | 1 | 311 | 311 |
| Metal Workshop II | 1 | 178 | 178 |
| Wood Workshop | 1 | 222 | 222 |
| Wood Machine Shop | 1 | 152 | 152 |
| Electrical Workshop | 1 | 178 | 178 |
| Technical Drawing Room | 2 | 133 | 266 |
| Technical Drawing Preparation Room | 1 | 27 | 27 |
| Tools Store | 1 | 20 | 20 |
| Science Facilities | | | |
| Science Laboratory | 5 | 131 | 131 |
| Science Store and Preparation Room | 8 | 22 | 176 |
| Home Economics Facilities | | | |
| Needlework and Drawing Room | 1 | 131 | 131 |
| Homecraft Room | 1 | 131 | 131 |
| Kitchen | 1 | 131 | 131 |
| Multi-purpose Room | 1 | 131 | 131 |
| Art and Crafts | | | |
| Art and Crafts Room | 2 | 131 | 262 |
| Casting Room | 2 | 22 | 44 |
| Store | 1 | 27 | 27 |
| 2. Ancillary Facilities | | | |
| Library | 1 | 128 | 128 |
| Audio Visual Aids Room | 1 | 131 | 131 |
| Extra-curricular Activities Room | 2 | 64 | 128 |
| Armoury | 1 | 30 | 30 |
| Bookshop | 1 | 27 | 27 |
| Prefects' Room | 1 | 25 | 25 |
| Hall | 1 | 664 | 664 |
| Canteen | 1 | 664 | 664 |
| Sick Bay | 1 | 30 | 30 |

Table 4. Space provision in a standard secondary school in Singapore (cont'd)

| Space | No. of units | Unit area (in $m^2$) | Total area (in $m^2$) |
|---|---|---|---|
| 3. Administrative Facilities | | | |
| Principal's Office | 1 | 27 | 27 |
| General Office | 1 | 37 | 37 |
| Staff Room | 1 | 96 | 96 |
| 4. Physical Education Play Area | | | |
| Basketball Court | 1 | 480 | 480 |
| Playfield | 1 | - | 7 000 |

Table 5. Space norms

| Area per place in educational areas[1] | | Lower and Upper Secondary |
|---|---|---|
| Classrooms | | 1.6 $m^2$ |
| Laboratories | | 3.4 $m^2$ |
| Workshops | Metal | 12.2 $m^2$ |
| | Woodwork | 9.4 $m^2$ |
| | Electricity/Electronics | 4.4 $m^2$ |
| Home Economics | | 4.0 $m^2$ |
| Special Rooms | | 1.6 $m^2$ |
| Others (Specify) | Technical Drawing Room | 4.0 $m^2$ |
| | Art and Crafts Room | 3.9 $m^2$ |
| Gross area per student | | 17.3 $m^2$ |
| Per school in hectares | | 3.03 ha |
| Area per place for play grounds/sports | | 4.8 $m^2$ |

1. Assumed 40 pupils per location; in an actual situation, the number of of students may be less than 40.

Chapter Two

# TECHNICAL EDUCATION IN GENERAL SECONDARY SCHOOLS

## Development of technical education

The development of workshops in the secondary schools reflects the changing attitudes, both educational and social, to the teaching of technical subjects within the school curriculum. In 1951, the Malayan Society of Engineers carried out a survey into the shortage of draughtsmen and technicians and urged that measures were necessary to establish training facilities to overcome the problem. In 1953, the Dobby Committee reported that "there is an immediate need for a Polytechnic" in Singapore.[1]

Educational policy, during the late 1950s especially, stressed the importance of technical education and training to match the manpower requirements for industry and a Commission of Inquiry into Technical and Vocational Education in Singapore was set up in 1960. The system of school education which emerged led to the establishment of four types of secondary school as follows:[2]

1. Academic school - designed to offer a four-year, general education course in which students may choose an arts, a commercial or a science biased curriculum leading to the GCE 'O' Level Certificate.
2. Technical school - designed to offer a four-year general course with a bias towards technical education leading to the GCE 'O' Level Certificate.
3. Multi-purpose school - a combination of the above two types of schools.
4. Vocational school - designed to offer special two-year courses, with a practical bias for students who have merely completed primary education and who have attained the age of 14. The course led to the Vocational School Certificate.

In 1968, it became abundantly clear that the output from the technical stream of the schools was still very much below expectations. Out of every 100 students who then completed secondary education, 92 were from the academic stream, two were from the commercial stream and only six were from the technical stream.[3]

---

1. Committee on a Polytechnic Institute for Singapore. *Report*. Singapore, Government Printing Office, 1953. p. 11, para 18.
2. Singapore. Ministry of Education. Technical Education Department. *One year of technical education 1968-1969*. Singapore, Government Printing Office, 1969.
3. _____. _____. _____. _____: p 4.

The National Industrial Training Council, formed in 1968 at ministerial level,[4] viewed this situation with grave concern and felt that such a preponderence of school leavers with a purely academic education was not in harmony with the national objective of producing students trained to enter industry. The Minister for Education in his foreword to Education in Singapore 1969 states "... the aims and content of education are being re-orientated to evolve an educational system which will support and develop the Republic as a modern industrial nation.... The seventies will see the qualitative improvement of education as well as the evolution of a sound educational system with a strong technical education component."[5]

Consequently, under the new system the secondary vocational schools were phased out, as they were unpopular and did not endow their graduates with marketable skills. The multi-purpose schools never really functioned because they were overtaken by the new policy changes before they could even open.

## A technical stream in general education

From 1969, a common curriculum was introduced for Secondary 1 and Secondary 2, in which, in addition to the usual subjects, all boys and 50 per cent of the girls were required to study technical drawing and workshop subjects.[6] On completion of Secondary 2, students underwent an exercise as a result of which all parents were given the option to decide upon the type of education, either technical or academic, that they desired for their children. Final channelling of students, however, was dependent upon their percentile ranking in the aptitude tests, together with an evaluation of their performance in the group of cognate subjects and the workshop subjects.

One factor which discouraged a large number of students from opting for technical education was that they would have to transfer to technical schools (schools with workshop facilities). Hence, most students opted against the technical stream because they preferred to stay on in their own schools. This led to a decision that all new secondary schools are now to be equipped with their own workshop blocks.

At the time, however, and in order to overcome this limitation, a centralized workshops scheme was started to serve the schools of a particular area on a regional basis.[7] Generally, instructional sessions in these workshops were limited to one per week only and the posting of students took special account of the bus routes available for them to travel between the centralized workshop and their school. The centralized workshops scheme

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4. Ibid.

5. Singapore. Ministry of Education. *Education in Singapore.* 1st ed. Singapore, Educational Publications Bureau, 1969. foreword page.

6. _____. _____. _____. 2nd ed. Singapore, Educational Publications Bureau, 1972. p. 22.

7. Singh, Harbans P. *Centralised workshops in Singapore.* Bangkok, Unesco, 1975. (ACEID Education and Work 1).

has been well accepted and it has been possible to attract the comparatively better and more technically inclined students to the technical stream after Secondary 2. Another tremendous advantage is that it has been possible to achieve the utmost utilization of expensive workshop facilities, thus preventing wastage of public funds.

The present policy is to maintain an approximate ratio of 3:1 distribution between students of the academic stream and the technical stream. Workshop facilities have been expanded to provide for the tremendous increase in enrolments since 1970.[8]

Following a review of the technical education programme in the secondary schools by the Shelley Committee, further adjustments to the secondary curriculum were made. A major recommendation led to the gradual phasing-out of technical drawing and basic electricity from the curriculum. This resulted in a reduction in the overall number of periods of Secondary 1 classes from 44 or 46 to 40 periods per week, with workshop practice being taken within the 40-period curriculum time.[9]

From 1977, boys in Secondary 1 continued to be required to do workshop practice as usual, but girls in Secondary 1 could choose to do either workshop practice or home economics instead of both subjects. This change of policy in respect of girls will, no doubt, affect the demand for workshop facilities at that level in future.

## Aims of the technical component in general education

Technical education within the school system does not provide any vocational training, but whatever is learned in the school workshop should help those who are by nature both active and inquisitive to understand their environment better. Thus, after leaving the school situation, students should have a very good opportunity of being considered for posts as industrial technicians or for enrolment in vocational training courses. In Singapore, therefore, schools aim at providing a broad technical education (besides general education) through:

a) Exposing students to practical activities in several areas;

b) Acquainting students with basic hand tools and simple machines and teaching them how to use them;

c) Familiarizing them with the rudiments of drawing and design related to their workshop practice.[10]

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8. Singapore. Ministry of Education. Technical Education Department. *4th Annual report 1971-1972*. Singapore, Government Printing Office, 1973. p. 5.

9. _____. _____. *Report of the Shelley Committee on the review of technical education in secondary schools*. 1976. Unpublished.

10. Seminar on Technical Education and Industrial Training in Singapore, *Report*, Singapore, Technical Education Society, 1973.

The inclusion of technical subjects in the school curriculum is amply justified by their subsequent educational value and by the strength of their appeal to adolescent students. It is not out of place to stress that these subjects are also primarily important for the following reasons:

a) With products of technology all about us and with almost everyone being able to use power-driven electrical or mechanical devices, our education must reflect this technological change in our way of life;

b) Our basic education in technical subjects should make it easier for our young people to adapt themselves to retraining at times of rapid technological change;

c) It is imperative that the spirit of fine craftsmanship be fostered in our secondary schools because future industries will increasingly require higher degrees of skill.

At the lower secondary level, workshop practice is provided within the 40-period curriculum time in two technical subjects, metalwork and woodwork, with one hour for metalwork weekly and one hour on alternate weeks for woodwork and workshop technology.

On completion of the lower secondary stage, students proceed to Secondary 3 and later to Secondary 4. Here, the curriculum is designed to provide a core of compulsory subjects and a range of electives. At this stage, students may offer various subject combinations depending upon their individual abilities and interests, and technical stream students are expected to study one workshop subject as an elective subject. For example, the high achievers take seven or eight subjects while the large majority of average pupils or those who are not too strongly inclined academically take six subjects. Thus these 'six-subject' pupils will have more time for their workshop subject as a preparation for future vocational training.

Chapter Three

# WORKSHOPS; GENERAL DESIGN CONSIDERATIONS

## Location and size of workshops

Workshops are not just large classrooms with benches for work. They have to be carefully and functionally designed to serve their purpose well. The facilities provided must satisfy the actual demands of the curriculum, cater for the course preferences of the students and be flexible enough to cope with changing educational policy.

The design of accommodation for technical education in secondary schools can be a complicated matter, demanding the closest co-operation of planners, educators, architects and administrators. The school workshop facilities in Singapore at present aim at providing opportunities for:

1. The younger students of varying abilities at all levels to follow a basic course in technical subjects;

2. The older students to pursue a course of specialized training in a technical subject leading to the GCE 'O' level examination. Some of the less able, older students also receive vocational orientation in allied metalworking and woodworking trades.

A workshop is generally located within the school compound, some distance away from the teaching areas of the school because of the noise from the machine shops. If possible, workshop blocks are not built parallel to the classroom teaching blocks. Where this is unavoidable, common-use areas such as school halls, assembly grounds and parade squares are placed adjacent to workshop blocks to separate them from the teaching areas. Covered passageways are provided to enable students to move to and from the workshop blocks (Figure 1). Access roads leading to the workshop blocks are wide enough to admit heavy vehicles and large doors are provided to the main storage and working areas so that heavy machinery and lengths of material can easily be brought in (Plate 1).

Workshop accommodation is provided in the ratio 2:1:1 for metalwork shops, woodwork shops and electricalwork shops respectively. This meets both the requirements of the curriculum and the usual student demand for courses of study. The workshop equipment and spaces provided are sufficient to permit various arrangements of the technical education curriculum up to the GCE 'O' Level, while also allowing vocational orientation of students who need better grounding for future skill training. The accommodation provided is sufficient to cater for the needs of 46 classes or 1,840 students in the technical stream of a typical secondary school as shown in Table 6, page 14.

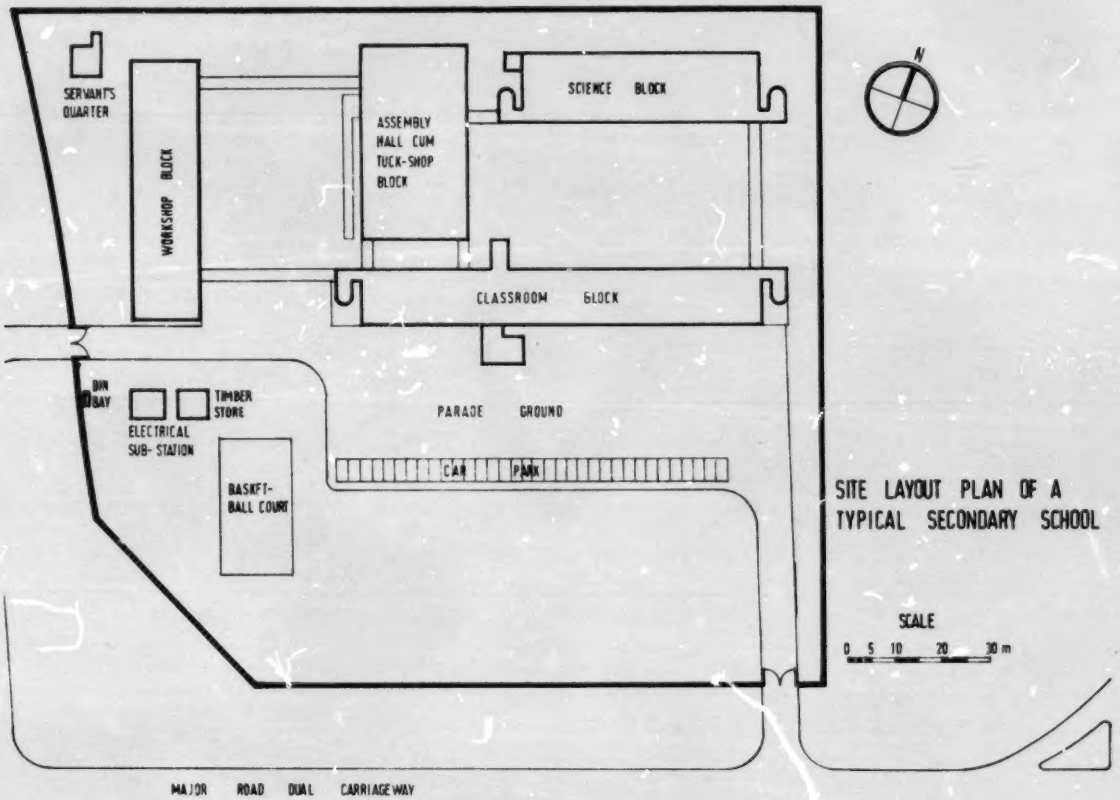



*Figure 1. Site-layout plan of a typical secondary school*

*Plate 1. Large doors to bring heavy machinery and lengths of material into the workshop*

Table 6. Workshop capacity

| Grade | No. of classes | Periods per week |
|---|---|---|
| Secondary 1 | 15 | 4 |
| Secondary 2 | 15 | 4 |
| Secondary 3 | 8 | 5 or 9 |
| Secondary 4 | 8 | 5 or 9 |

Each period is of 35 or 40 minutes' duration.

Ideally, all workshops should be located on the ground floor. But due to the shortage of land in Singapore it has become necessary to build multi-storied workshop blocks. The expense of building today also makes it necessary that every cubic metre of available space be carefully planned and utilized. Generally, heavy machinery and material storage/preparation areas are on the ground floor. Details of the workshop facilities presently provided are given in Table 7 and shown in Figure 2.

Table 7. Approved workshop areas and locations

| Workshop | Area (sq m) | Floor Location | Remarks |
|---|---|---|---|
| Metalwork shop I | 312 | Ground | Fitting and machinery |
| Metalwork shop II | 179 | First | Fitting sheetmetal |
| Wood-machine shop | 150 | Ground | Timber preparation |
| Woodwork shop | 223* | First | General woodwork |
| Electrical shop | 178 | First | Laboratory work |
| Technical drawing rooms (2 nos) | 269 | Second | Draughting |
| Preparation room | 26 | Ground | Teaching material preparation |
| Miscellaneous stores | 76+** | Ground | Timber tool storage |

Notes: * Includes 34 sq m for polishing room.
** Includes 34 sq m for timber shed to be built outside the workshop block.

Workshop design generally

A good workshop is a safe workshop. When designing the layout of operational areas, particular attention is paid to:

1. Siting of work-benches, machinery and apparatus so that unnecessary movement about the workshops is reduced;
2. Freeways to allow for necessary movement within the workshops without interference with other working areas;
3. Making it possible for the instructors to supervise their students and come to their aid, speedily, if necessary;

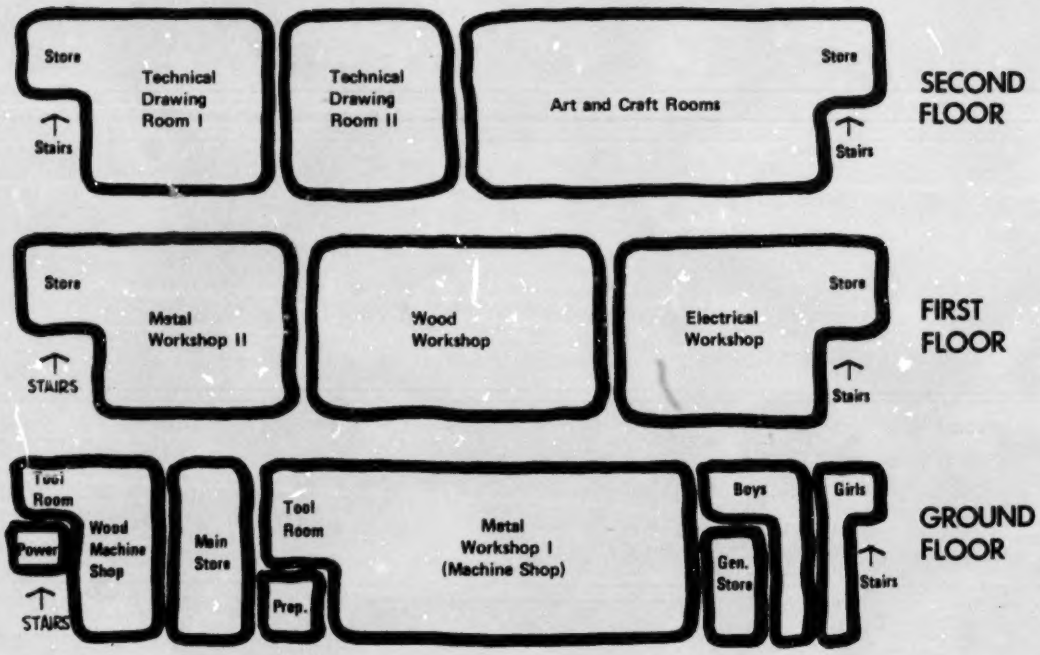



*Figure 2.*
*Schematic layout of workshop facilities*

4. Provision of non-slip floor surfaces;
5. Provision of enough emergency stop-switches to isolate the power supply to machines during an emergency;
6. Provision of non-return valves in the gas supply;
7. Supply and correct location of fire equipment and first-aid boxes.

General rules governing the proper conduct of workshop practice are also provided. The rules stress that safety is largely dependent upon knowledge and common sense. (Appendix I)

Ventilation. The building design allows for adequate cross-ventilation in the workshops. Ceiling fans are also provided to improve air circulation while - in addition - extractor fans are installed to rid the area near the forges of dust and fumes likely to be generated there (Plate 2).

Lighting. Artificial illumination provided by fluorescent fittings is generally found to be suitable but local lighting of the low-voltage type is also provided on individual machines such as lathes, and to guard against dangers resulting from possible stroboscopic effects.[1] Illumination during day-time is enhanced by off-white colouring of the ceilings to give reflected light, and low-level louvred glass windows (Plate 3).

1. Fluorescent light comprises a large number of electrical discharges per second and this gives the *appearance* of a continuous light source. When the frequency of discharge is precisely the same as the frequency of rotation of a wheel, such as the chuck of a lathe, however, the chuck appears to be *stationary*. This is highly dangerous.

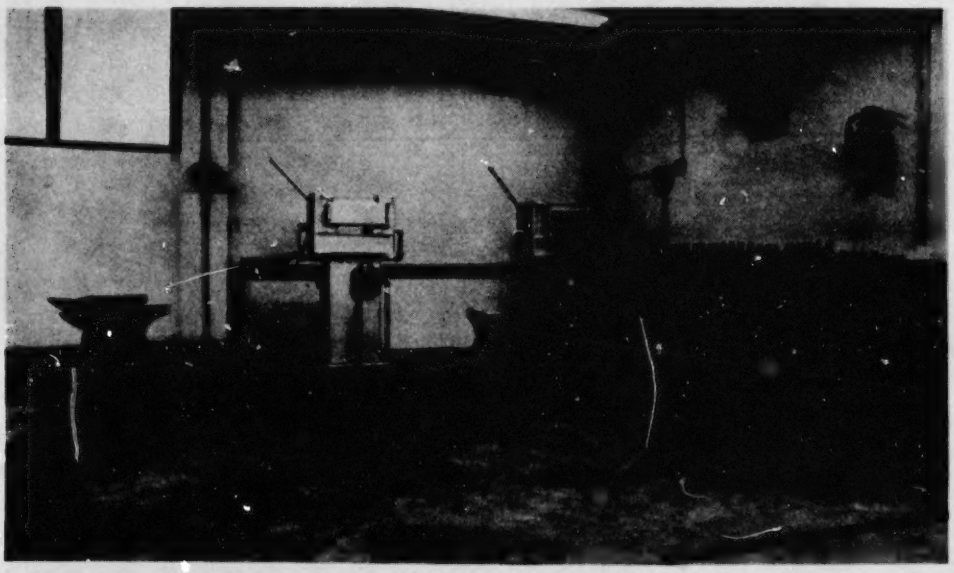


*Plate 2. Fans in the top of the wall near the window extract dust and fumes from the forges*

*Plate 3. Illumination levels are raised by light-coloured ceilings and low-level windows*

Separate switchboards for electrical circuits supplying 440 volts (3-phase) and 230-volt (single-phase) alternating current are provided. Generally, 440-volt (3-phase) machines are individually fitted with isolator switches and on/off push-button starters. Micro switches are also required to be provided to guards and doors to moving parts of machines. Emergency stop-switches are provided all round the machine shop at convenient points and everyone using the workshop is required to know their exact locations and their use (Plate 4).

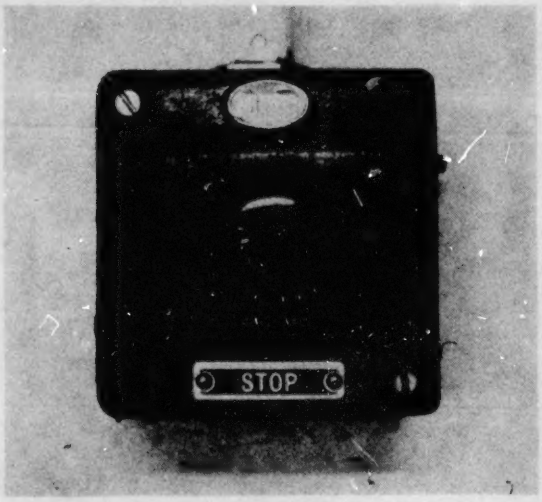



*Plate 4. An emergency stop-switch, the use of which cuts off all electric power in the workshop*

Sufficient panels of soft wallboard are provided for pinning up wall charts and other forms of visual aid to be displayed in the workshops. Glass-fronted cupboards are included in the standard furniture-list to encourage schools to exhibit work produced by the students.

Special consideration is given to the provision of storage facilities in the workshops. Every workroom has tool rooms or stores for keeping materials and tools in current use (Plates 5, 6 and 7). Low, built-in cupboards are provided for storing work in progress. The Main Store provides ample space for the storage of bulk supplies (Plate 8).

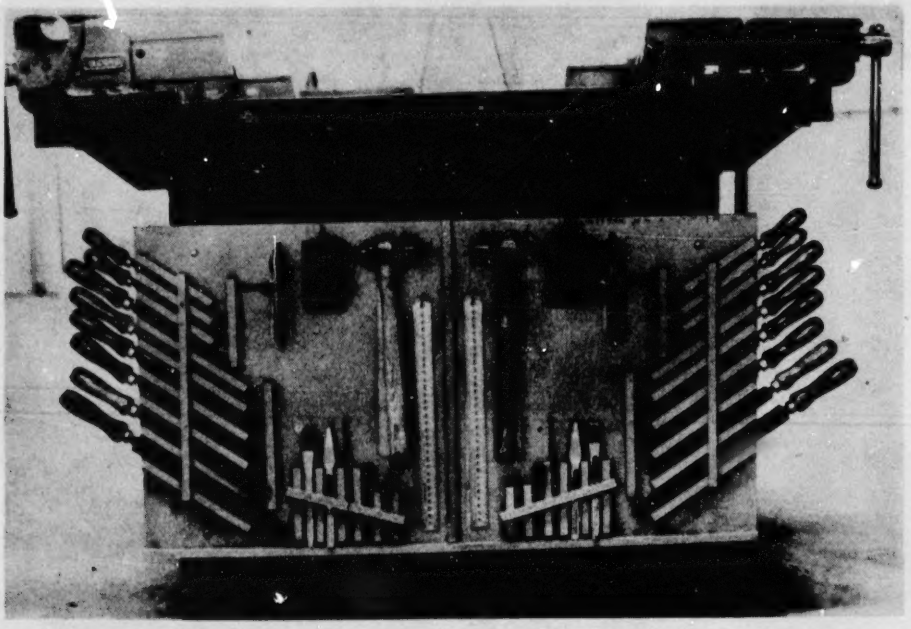


*Plate 5. Fitters' tools, ready for benchwork located at the end of the bench*

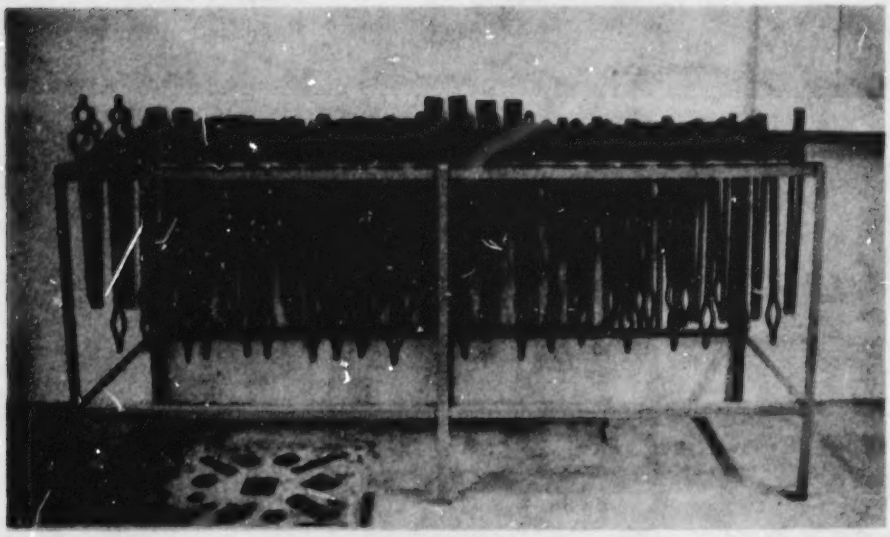


*Plate 6. Tools for forge work grouped in racks at a central point in the forge*

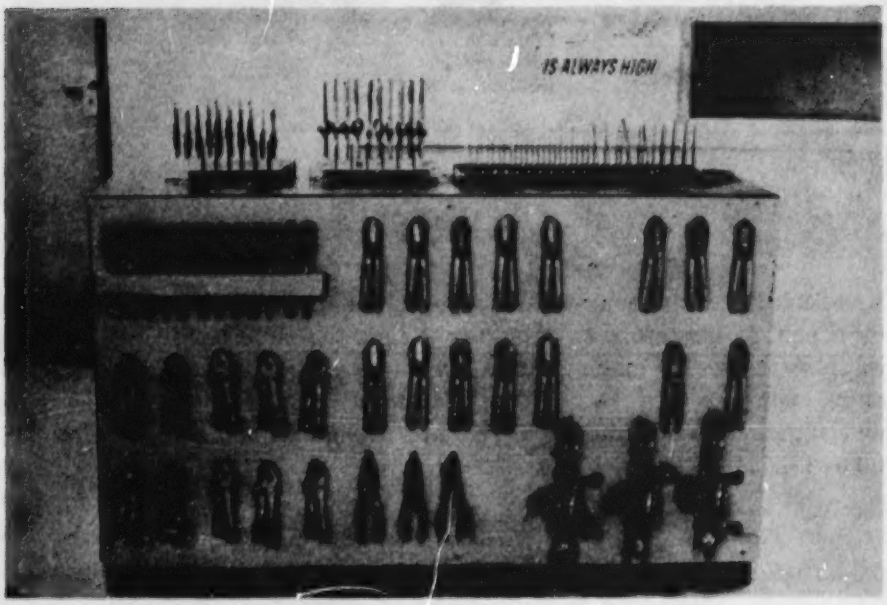



*Plate 7. Open storage of tools for fitting and sheet metalwork*

Workshops which are now being built are generally simple, well-constructed, spacious, well-lit, airy and suitable for the intended purpose. The colour-scheme for walls, fittings and ceilings is cheerful and neat in order to create a healthy workshop atmosphere. Floors are solid, smooth concrete, not always comfortable to the feet, but not slippery and easy to keep clean.

*Plate 8. The main store has ample capacity for bulk supplies*

Several activities are usually going on at the same time in a workshop. It is necessary therefore to provide the best possible conditions for carrying out each operation by ensuring that free and safe movement can take place when changing from one area to another. Minimum safe distances to be maintained around fixed equipment in the workshops are given in Table 8. The situations listed are illustrated in Figure 3.

Table 8. Recommended safe distances around benches and fixed equipment in workshops

| Work area | Safe distance (m) |
|---|---|
| a) Bench side and bench end | 1.25 |
| b) Bench end and fixed equipment | 1.40 |
| c) Bench end and bench end | 1.25 |
| d) Between adjacent bench sides | 1.40 |
| e) Bench side and fixed equipment | 1.80 |
| f) Unrestricted area in front of operator's end of machine | 1.00 |

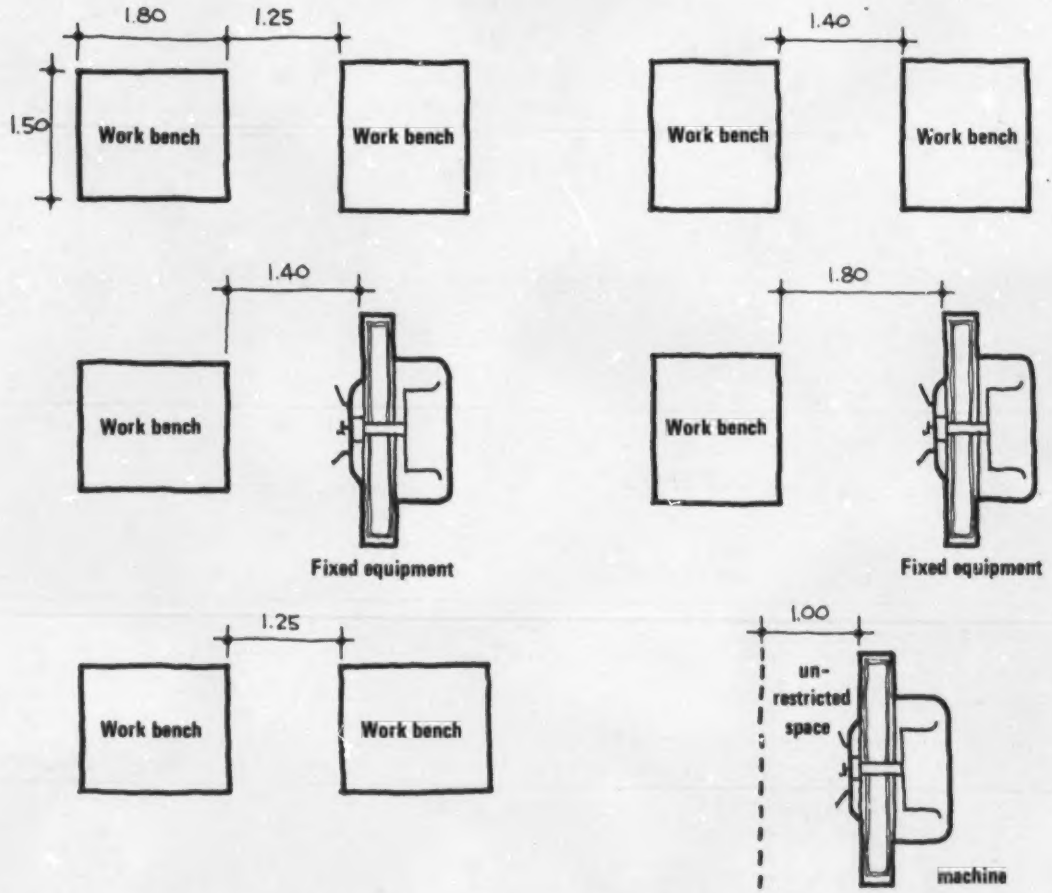



*Figure 3. Recommended safe distances around benches and fixed equipment in workshops*

Chapter Four

# WORKSHOPS; DETAILED DESIGN CONSIDERATIONS

## Metalwork shops

The course in metalwork aims at providing training as indicated below.

a) Bench work. Filing straight and curved edges; drilling; riveting; thread forming with tap and die; bending; brazing; simple fitting.

b) Tinplate work. Forming a safe edge; forming a folded seam joint; forming and soldering a grooved seam joint; forming and soldering a lap joint; forming a wired edge; flanging a circular disc.

c) Brass and copper work. Sinking; hollowing; raising; planishing; built-up work comprising bending pieces of brass or copper with various shapes; forming a butt-seam and flaring the seamed form; silver soldering.

d) Forge work. Drawing down; simple bending; up-setting; fullering; swaging; punching and drifting; cutting; twisting; eye forming; flaring or flattening; hardening and tempering.

e) Machine work

i) Centre lathe–Simple turning processes including use a 3-jaw chuck and between centre work: parallel turning, facing, centering, parting-off, knurling, drilling; reaming and boring to caliper and micrometer size. The use of taps and dies on the lathe. Taper turning using compound slide.

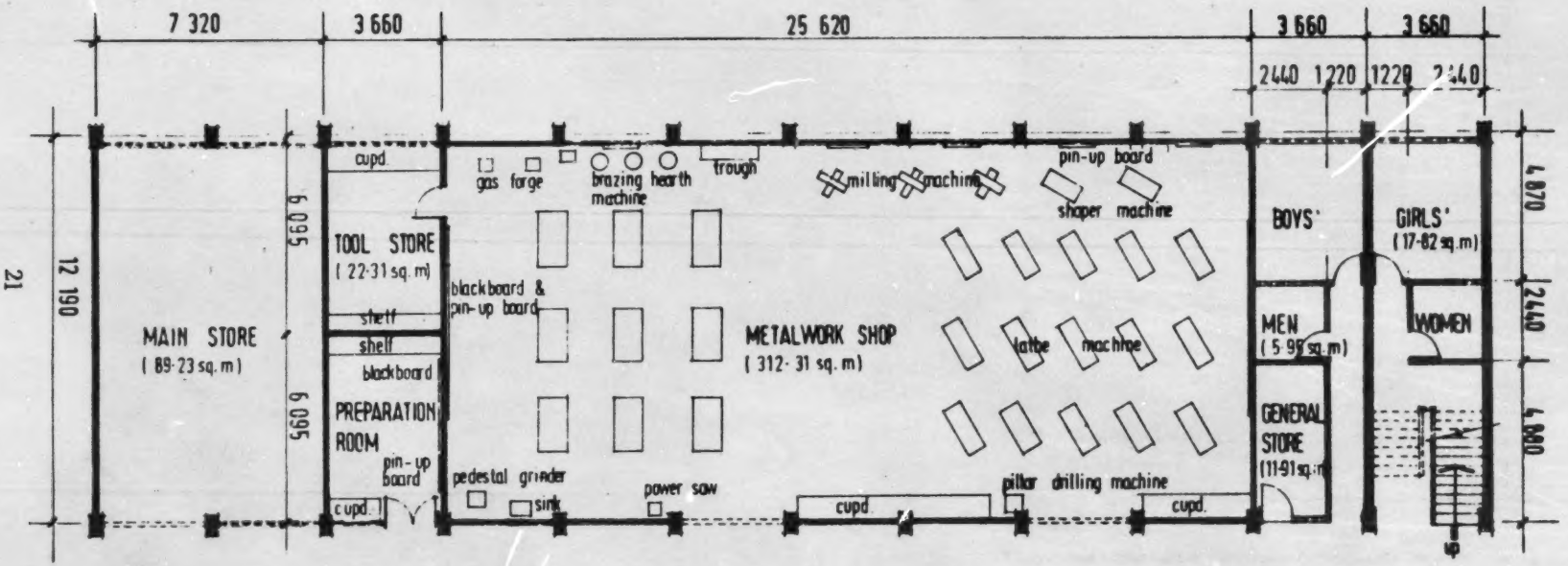
ii) Shaping machine–Simple roughing and finishing of plain surfaces.

iii) Milling machine–Simple slab-milling and facing of plain surfaces.

Figures 4 and 5 show plans of the two standard metalwork shops.

A corner of the workshop, which is provided with a chalkboard, pin-up boards, 13-amp switch-plug and a work bench, can be developed as an area in which the teacher can talk to his group of about 20 students. Here he may draw or write, display information, show slides or demonstrate to them. With the glass-front cupboards and the teacher's desk and chair

*Figure 4. Layout plan of metalwork shop on ground floor*



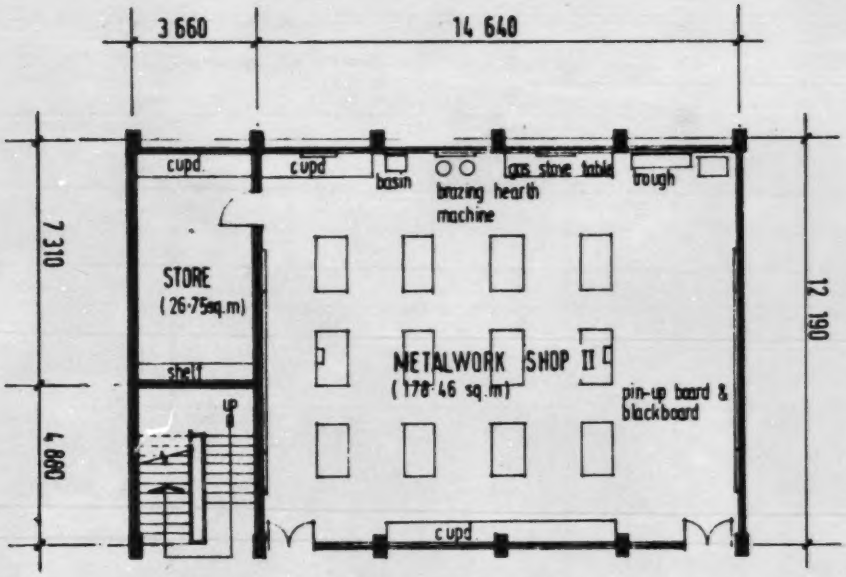



*Figure 5. Layout plan of metalwork shop II on first floor*

provided, the place can easily be organized into a space for planning and reference as well. Here, the teacher can organize his work and have all books, papers, drawings, records and other paraphernalia near at hand. It would also be a clean place to keep the first-aid box (Plate 9).

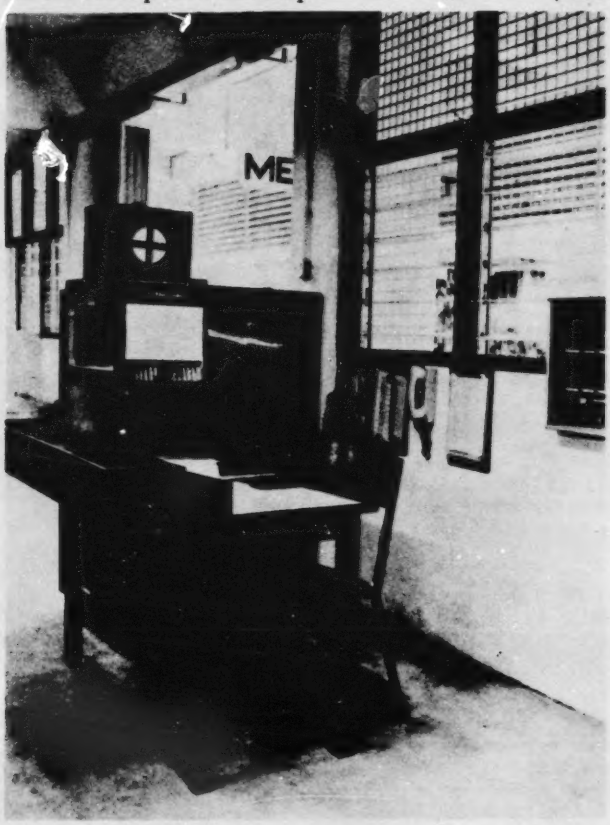


*Plate 9. The teacher's work-place in the metal-work shop*

Each metalwork shop is supplied with four-station work benches (each 1.80 x 1.50 x 0.78 metres), sufficient to accommodate a class of 40 students with two teachers in charge. Each bench is of heavy, angle-welded frame construction fitted with 5-cm-thick hardwood top and a 10-cm fitter's vice fixed on each corner of the bench. Tool storage space is also provided at each work bench (see Plate 5). Teachers are allowed the flexibility of setting out the work benches to suit their individual tastes, provided the necessary suggested safe distances mentioned previously are respected. Each teacher is provided with his own demonstration bench. A typical arrangement of fitters' benches is shown in Plate 10.

*Plate 10. A typical arrangement of fitters' benches*

Several types of machines are provided in metalwork shops. Precision machines (listed below) are as a rule, grouped away from the work-areas which are a potential source of harmful dust and fumes. Power-supplies and connections are as specified previously. The machines include:

a) Centre lathes, usually set an an angle to the walls so that if anything flies out of a lathe it will not strike the operator behind. Lathes selected for use in secondary schools are required to be sturdy, able to withstand unskilled usage and fitted with safety devices for preventing injury (Plate 11).

b) Milling machines and shaping machines, which are of the motorized type. They are placed some distance away from the wall to ensure that the drawbolt of the miller can be withdrawn with ease and that the shaper can operate on full stroke in extreme positions. Sufficient working space is provided around the machines for the operator to manoeuvre safely and comfortably.

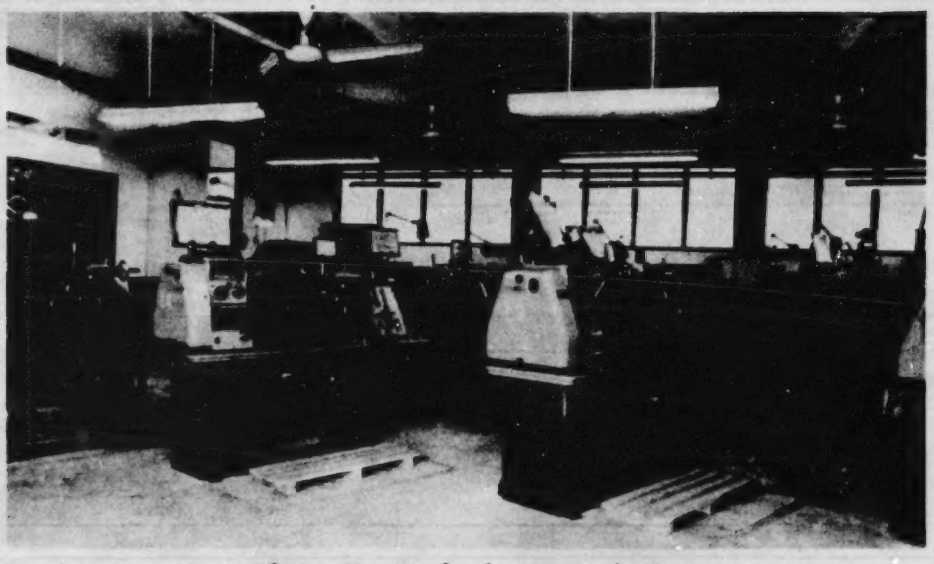


*Plate 11. Typical centre lathes*

c) Drilling machines are positioned so that they are convenient to those working at the benches and receive good natural light (Plate 12).

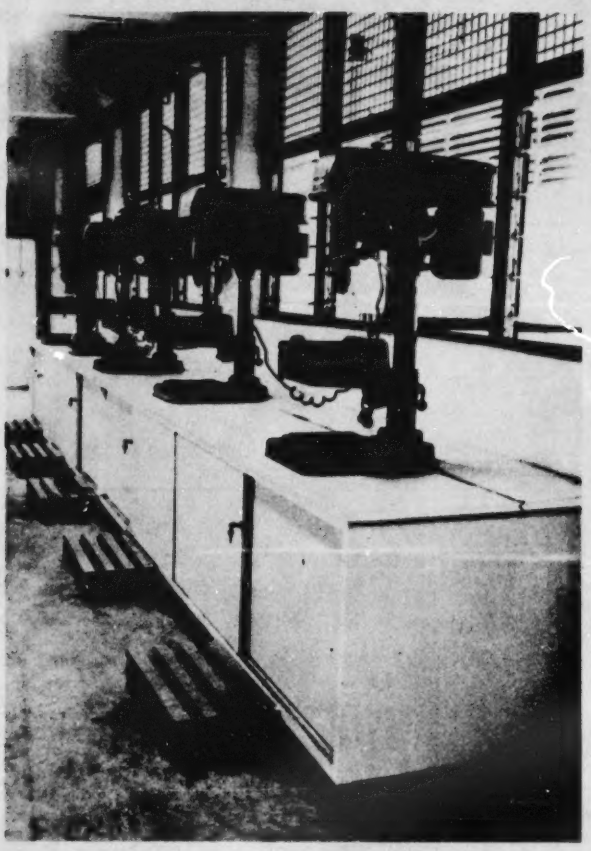


*Plate 12. Drilling machines located for good illumination*

d) Power saw and treadle guillotine are generally placed near or in the store with sufficient space being allowed for lengths of material to be cut without obstructing passageways (Plate 1).

Other related areas include those for forgework, brazing, soft-soldering, grinding and polishing, and - because they produce dust and fumes - are located away from the precision machines.

Forging is best done in a corner in subdued light, preferably in the darkest corner of the workshop, so that the worker can easily judge the correct heat from the colour of the hot metal. Even the wals here should be finished in a dark colour. Also the whole area should be well ventilated and an efficient air-extraction system provided to remove the fumes and dust which will be produced. Gas-fired forges are now supplied to schools as they occupy less space and cost less both to buy and install than the traditional blacksmith's hearth. They are also both more pollution-free and more efficient. A clear space of about 5.5 square metres must be provided in front of the forge for the two or three anvils, a leg-vice and a swage block needed in forging. A wall-rack for keeping anvils and forge tools is essential. A water trough (60 x 30 x 30 cm) should be installed nearby for cooling metal and tools, when necessary.

Brazing hearths of the circular type, with small compressors driven by an electric motor, are supplied to schools. Each hearth is fitted with a 12 mm gas blowpipe having independent controls for gas and air (Plate 13). Facilities for an acid 'pickle' bath, scouring and cleaning as well as a sink are close to the brazing or hard-soldering area.

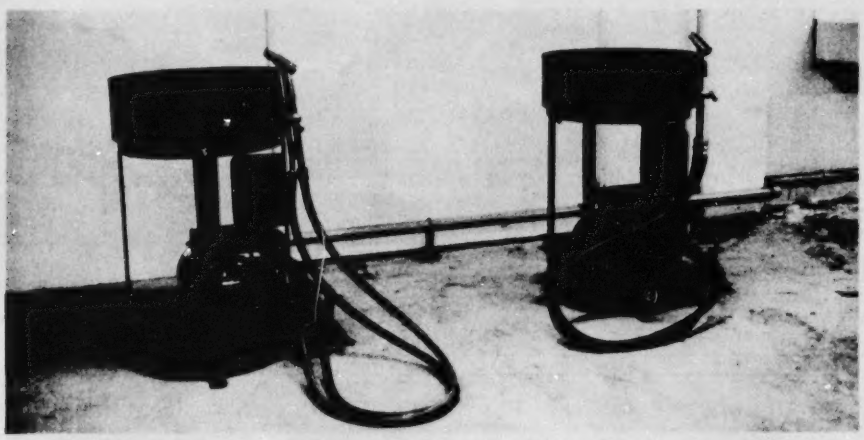


*Plate 13. Brazing hearths of the circular type*

A concrete bench with gas-heated stoves for soft-soldering, enough for six students to use at the same time is also provided with a control tap in front of each gas stove (Plate 14).

Grinding and polishing, unlike brazing and forging, require a well-lit area. Since grinders produce carborundum dust which can damage bearings and moving parts they are installed as far away from the precision machines as possible. The buff, which also produces a lot of greasy and abrasive

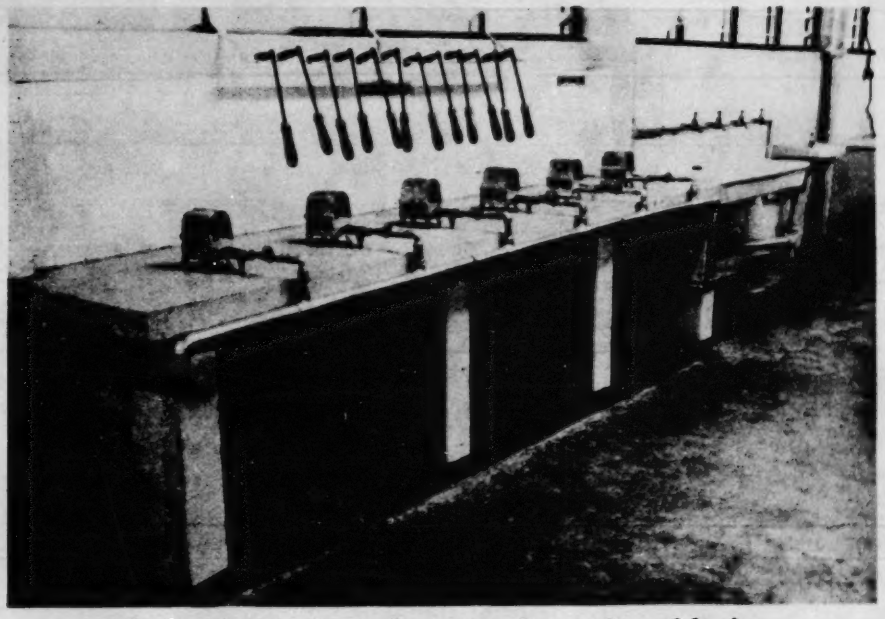


*Plate 14. Gas-heated stoves for soft soldering*

dirt, is best located some distance away from the precision machine area but reasonably close to the beaten-metalwork bench.

Woodwork shop

Woodwork provides training in the common methods of shaping and joining timber.

a) The common methods of shaping referred to are:

Sawing - with and across the grain; through and stopped;
Planning - surface, edge and end;
Chiselling - with, across and inclined to the grain;
Boring;
Spoke-shaving.

b) The common joints are:

Housing - through, stopped and simple dovetail;
Rebate (as in box construction);
Half-lap or half-check, plain and dovetailed; through and stopped;
Halved or cross;
Mortise and tenon - plain, haunched with and without a groove and a rebate;
Dovetail - plain and lapped (as in drawer construction);
Edge-joint with the grain, glued and rubbed, or with dowels, or with grooves and 'loose' feather or tongue;
Edge-joint with grain, tongued and grooved;
Dowelled joint;
Veneering; stringing, banding, inlays;
Finishes - staining, polishing, painting.

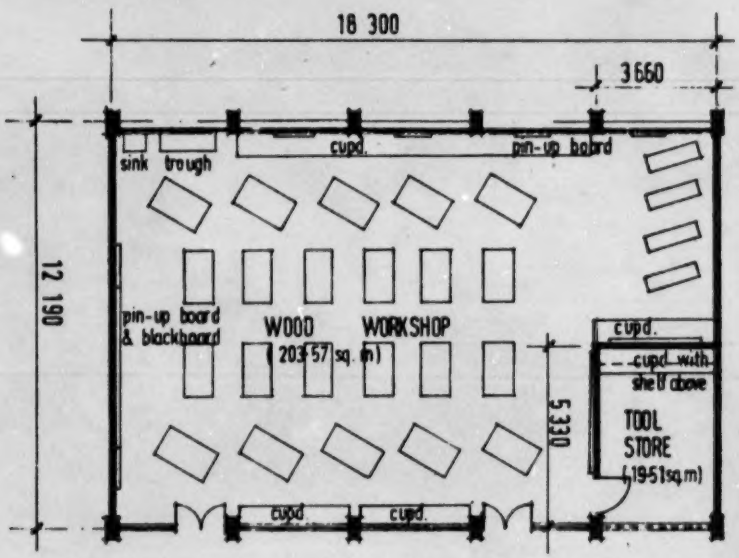
c) Instruction and practice is given in:

Simple wood-turning (face-plate and between centres);
The setting of a plane and the grinding and sharpening of chisels and plane irons;

d) The appropriate use and fitting of the following is taught:

Hinges - tee, back-flap, butt;
Locks - till, desk, rim;
Fastenings - slip-bolts, plain and flush, hasp and staple, ball catches, magnetic and nylon catches.

All of these aspects of the work find reflection in the design of the woodwork shops shown in Figure 6.



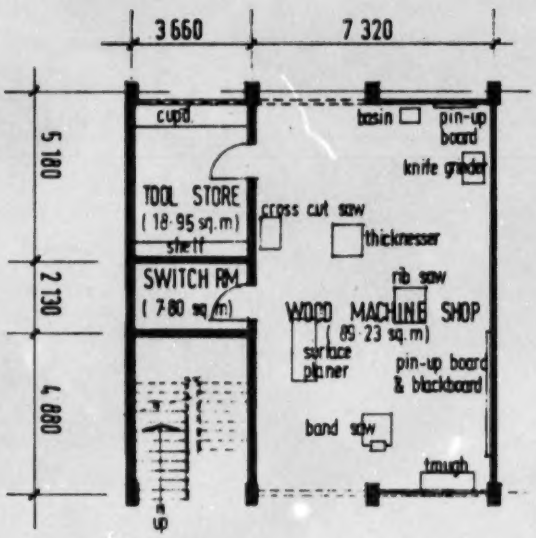




*Figure 6. (above) Layout plan of wood workshop (Workshop block, ground floor)*

*(right) Layout plan of wood machine shop (Workshop block, ground floor)*

The needs of the woodwork teacher are similar to those of the metalwork teacher, and suggestions made in the second paragraph of this Chapter apply here.

Each woodwork shop is supplied with two-station workbenches (1.50 x 0.75 x 0.80 metres), with wood vices of the quick-release type fitted to the long sides. Woodwork benches are specially made with hard tops about 75 mm thick with a central well to prevent tools with sharp edges from rolling on to the floor. A tool-cupboard with racks is also provided for storing the basic tools on the bench itself. The benches provided are sufficient to handle a class of 40 students, supervised by two teachers (Plate 15).

The woodwork shop is provided with a selection of less dangerous, wood-cutting machines, some of which are also provided to the wood-machine shop. The machines are as follows:

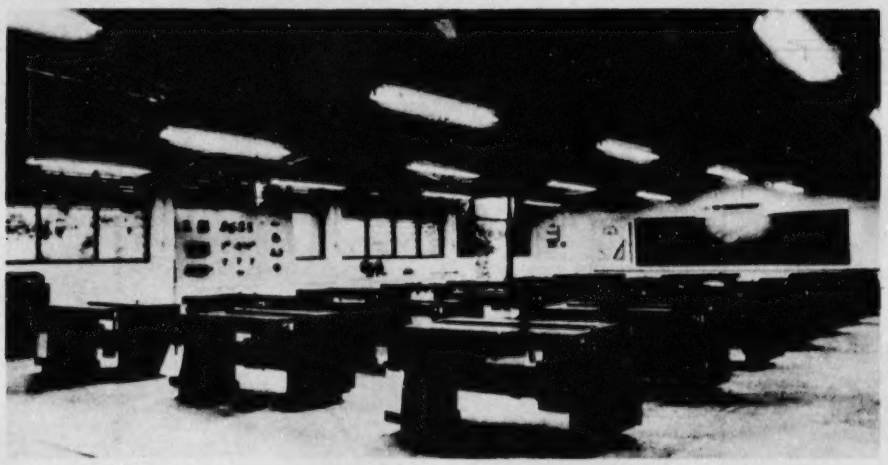


*Plate 15. The woodwork shop with 2-station work benches*

a) Wood turning lathes - There are usually three or four of these placed so that they receive good natural light and are clear of the other work areas (Plate 16).

*Plate 16. Wood-turning lathes positioned to receive good natural light*

b) Drilling machines for boring and drilling are provided - one or two in each workshop.

c) Double-ended grinder for simple sharpening of tools and other grinding operations.

d) Sharp-edge machines have now been added as they are more efficient, precise and require minimum skill and effort to carry out the sharpening of tools.

Wood machine shop

The wood machine shop is provided with one of each of the following machines: crosscut saw, circular (rip) saw, thicknesser, surface planer band saw and mortiser. Most of these machines are for conversion of timber from large to smaller sizes and students do not normally use them. The machines are specially housed in a separate area close to the timber shed. No unauthorized person is allowed the use of these machines (Plate 7).

Gluing, assembly, polishing, painting and finishing are carried out in a dust-free, special corner of the workshop away from the woodwork benches and wood-turning lathes. This area also houses the glue pots (electrical type) and the various types of clamps and holding devices.

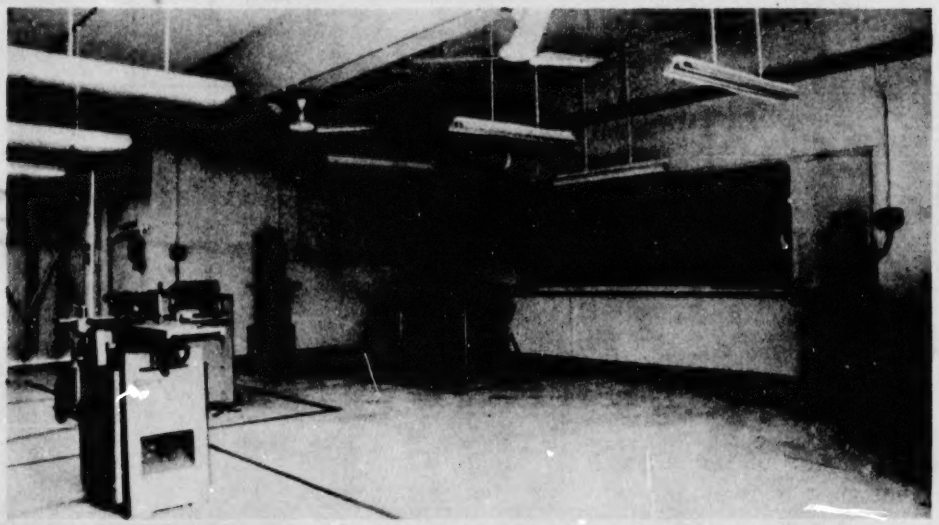


*Plate 17. Machines in the machine woodwork shop*

Electricity and electronics

The approach to the teaching of the subject is experimental and students are provided opportunities for constructing projects to apply what they have learned. Course work aims at improving the students' understanding of the fundamental principles and the application of these principles to problem-solving situations. The main topics covered are:

a) Direct current - production of DC current, types of DC circuits and their application in daily use and industry.

b) Alternating current - generation of AC, transformation of AC, effects of AC and their uses, and applications in the home and in industry.

c) Safety devices - types of safety device and purposes of using such devices in AC and DC circuits.

d) Introduction to electronics - types of electronic circuits and their related components, characteristics and uses of the various types of circuits.

e) Test-instruments - common types of electronic test instruments, their characteristics and their uses. Maintenance of test-instruments.

Figure 7 gives a layout plan of the electrical workshop.

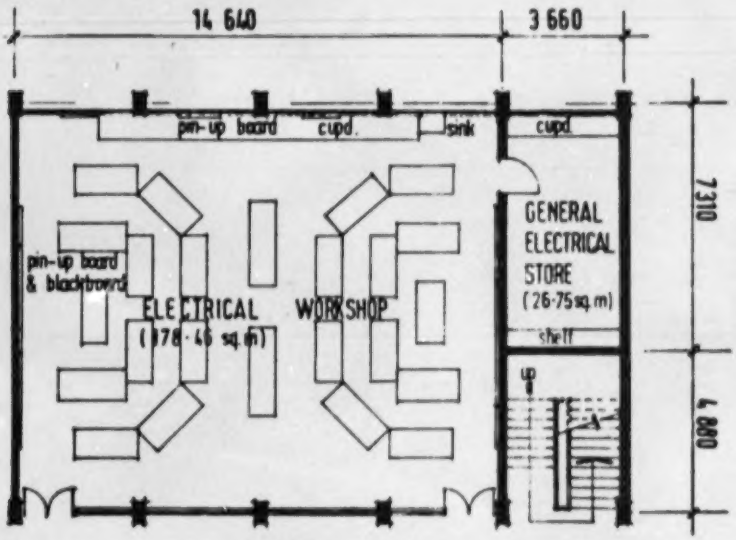



*Figure 7. Layout plan of the electrical workshop (Workshop block, ground floor)*

The needs of the electrical teacher for a demonstration are much more important than is the case with metalwork and the woodwork teachers. All electrical workshops are also well provided with special equipment for projection by overhead transparency and film slide or film strip.

Each electrical workbench (0.78 x 1.80 x 0.79 metres) is suitable for two students to work together. The benches are supplied with 230 volt, AC power and sufficient outlets are provided to enable each pupil to work independently, if necessary (Plate 18). The work benches are usually arranged in a 'U' shaped pattern, at each end of the workshop, so that two groups of 20 students each can be taken by two teachers (see Figure 7 and Plate 19).

A couple of workbenches fitted with bench vices, a bench grinder and a drilling machine are also provided for constructing parts of models and projects in the electrical shop.

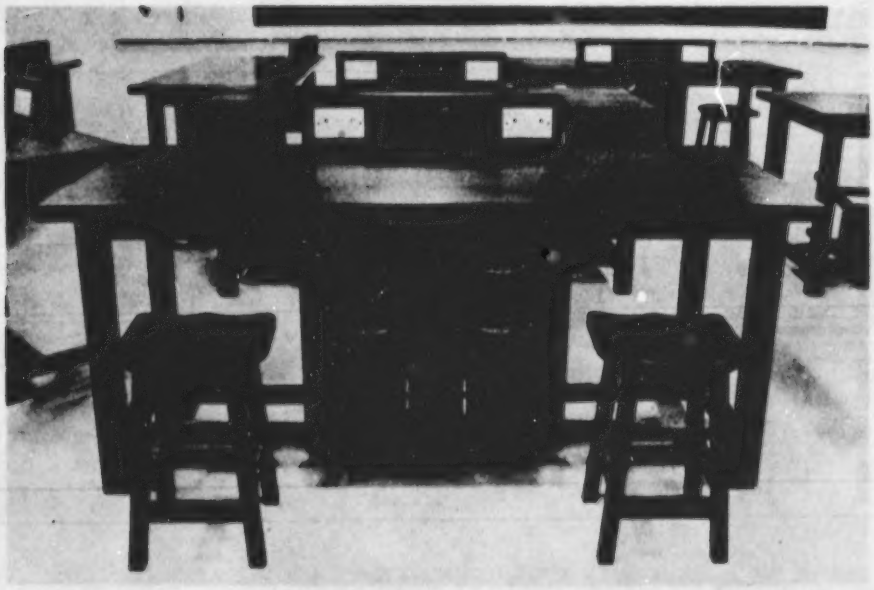


*Plate 18. An electrical work-bench for two students*

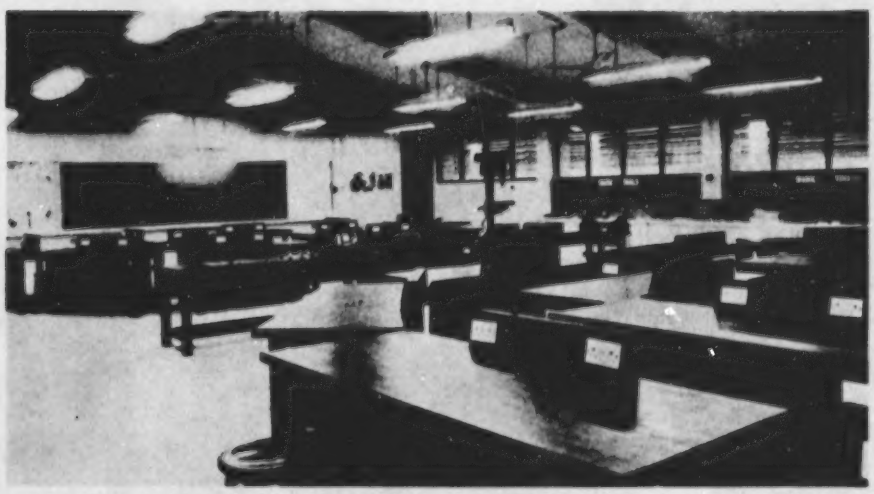


*Plate 19. Benches arranged in a U-shape in the electrical workshop*

Technical drawing

Technical drawing is compulsory for the technical stream and special rooms are being provided for its teaching (Figure 8). Its relevance to present-day conditions is however being seriously questioned, and its real status is likely to depend on it being more closely associated with the workshop subjects and eventually emerging as an effective language of the craftsman. Every school is provided with two technical drawing rooms, each designed and equipped for classes of 40 students under the charge of a teacher. Good natural and artificial lighting is considered essential (Plate 20).

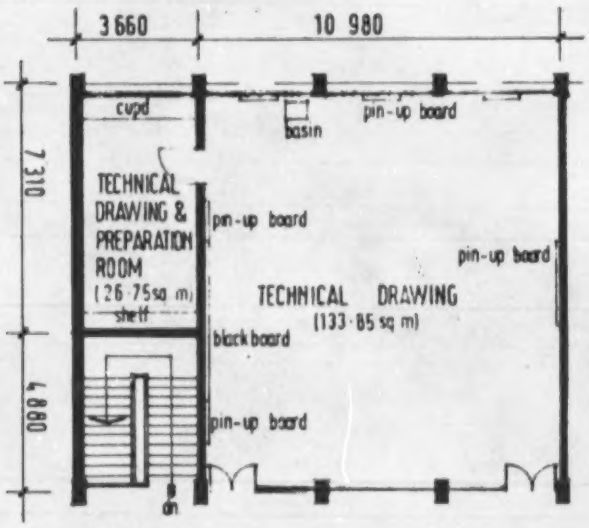



*Figure 8. Layout plan of technical drawing room (Workshop block, second floor)*

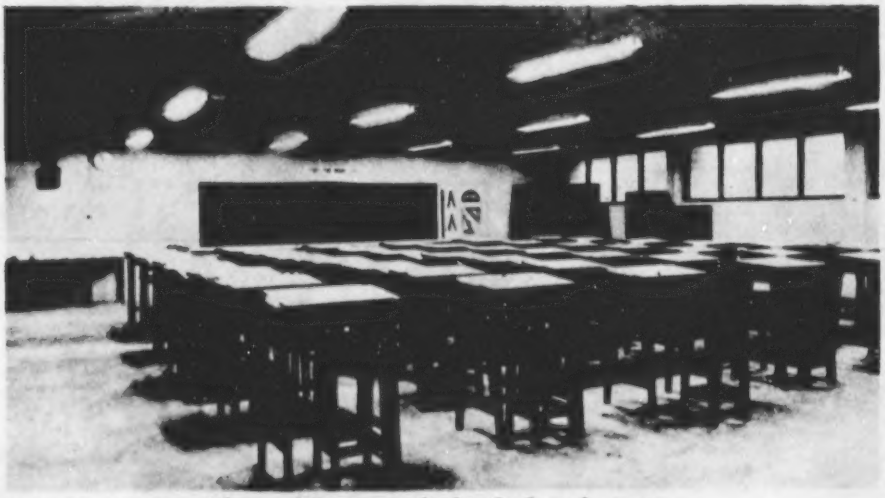


*Plate 20. A technical drawing room*

The teacher generally employs class teaching methods and stations himself in front of the class. A large chalkboard, complete with a set of drafting instruments, is available for making drawings. Softboards are also provided in front of the class for displaying drawings or projecting transparencies and film strips or slides, when required. Every pupil has the use of an individual drawing table, a drawing board and a T-square. The drawing table is designed with a fixed-slant top sufficient to receive an A. 2-size drawing board.[1] The fixed-top table has been found to be more useful than the adjustable top as the latter is prone to be damaged more easily by the students (Plate 21).

1. The A.2 size, one of the series of German Industrial Standards ('DIN norms') is a rectangle 59.4 x 42 cm.

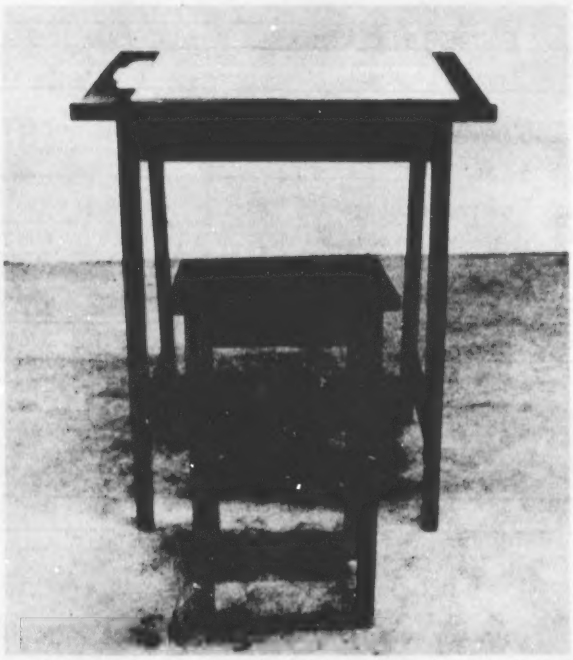


*Plate 21. An individual drawing table*

One of the drawing rooms is provided with a preparation-cum-store-room for keeping drawing materials, boards and instruments, and two and three dimensional display materials. It is also sufficient to house copying or printing machines for producing transparencies and duplicated material. Glass-fronted cupboards are usually supplied for keeping reference books, slides, films, film strips and other software or teaching materials.

Appendix

## GENERAL WORKSHOP RULES

1. Unauthorized persons are not permitted in the workshop.
2. No workshop practice is to be carried out by students in the absence of the teacher or instructor.
3. Always use the right tool for the right job and return it to its proper place after use.
4. Extreme care should be exercised when handling sharp-pointed or sharp-edged tools.
5. Do not use tools that are blunt, badly-worn, 'mushroomed' or in poor condition.
6. Students should not operate machines unless they have been instructed in their correct use.
7. All machinery should have safety-guards and protective gear.
8. All faulty tools and machines must be reported immediately and an 'OUT OF ORDER' sign prominently displayed on them.
9. All students and workshop staff should wear aprons or overalls during workshop sessions.
10. Shirts with long sleeves, watches, rings, bracelets and bangles should not be worn during workshop practice.
11. Every girl student should wear a scarf, a headband or a net to keep hair from becoming a hazard during workshop practice.
12. No eating or smoking is allowed in the workshop.
13. Do not rush. Watch your step while in the workshop.
14. Do not talk or walk about unnecessarily in the workshop.
15. When in doubt, always ask.
16. Every workshop must have a first-aid box prominently displayed, and easily accessible, with adequate supplies of medicine properly labelled.
17. Injuries, no matter how slight, should be given first-aid treatment and the injured immediately sent for medical attention, if necessary.
18. All accidents and injuries must be recorded.
19. All severe accidents caused by machinery and tools should be reported to the School Adviser/Technical, Ministry of Education, without delay. The machines involved in the accident must not be operated or tampered with until inspected by the school adviser.
20. Fire drill should be practised at least once a term. All fire-fighting equipment must be easily accessible and periodically checked.

# EDUCATIONAL BUILDING PUBLICATIONS

**BIBLIOGRAPHY**

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